REMARKS

Reexamination and reconsideration of this application as amended is requested. By this amendment, claims 1, 4-5, 8-11 and 15 have been amended, claims 2-3, 14, and 20-39 have been cancelled, and new claim 40 has been added. Claims 1, 4-13, 15-19, and 40 remain in the application.

RESTRICTION OF CLAIMS

The Examiner has restricted the claims to Group I (claims 1-19) and Group II (claims 20-39). Applicant hereby affirms the election of Group I (claims 1-19) without traverse, as previously made during a telephone conversation. Claims 20-39 have been cancelled.

OBJECTION TO THE DRAWINGS

The Examiner has objected to the drawings because none of the FIGs. identify the element 90. New drawings have been entered in compliance with this requirement. Red line drawings have been attached to this amendment for clarification to the Examiner.

Accordingly, it is believed that the objection to the drawings has been overcome by the amendment and remarks.

REJECTION OF CLAIMS 1 AND 6 UNDER 35 U.S.C. §112

Claims 1 and 6 have been rejected under 35 U.S.C. 112 as being indefinite.

Claims 1 and 6 have been amended where the catalytic particles are less than about 500 nanometers in diameter. Support may be found on page 10, lines 12-22.

Accordingly, it is believed that the rejection of claims 1 and 6 under 35 U.S.C. 112 has been overcome by the amendment and remarks.

REJECTION OF CLAIMS 1, 4, 6-8, 12, AND 14-16 UNDER 35 U.S.C. §102

Claims 1, 4, 6-8, 12, and 14-16 have been rejected under 35 U.S.C. 102 as being anticipated by Lee et al. (6,514,113).

The Lee patent reference discloses a light source using carbon nanotubes. A catalytic metal film 300 is grown over a metal film 200, which overlies a substrate 100. The catalytic metal film 300 is etched to provide "particles" which are actually islands on the metal film 200 (see FIG. 8; column 7, lines 44-48) on which the carbon nanotubes would grow. Although Lee shows in FIG. 3, for example, a layer with particles therein, he describes in column 5, lines 50-53 that the particles are isolated with the underlying metal film 200 exposed therebetween in deference to what is shown in the FIG. 3. Lee adds, "As a result, the catalytic metal film 300 is constituted by the isolated catalytic metal particles distributed independently."

The present invention teaches a field emission device, comprising a substrate and a nano-supported catalyst formed on said substrate. The nano-supported catalyst includes, in one embodiment, a mixed metal alloy sub-layer overlying said substrate, and a porous sub-layer overlying said mixed metal alloy sub-layer. The porous sub-layer includes active catalytic particles and nano-pores formed within a

metal oxide (for example) structure. At least one nanotube is catalytically formed in situ on said nano-supported catalyst.

The present invention differs from the cited Lee patent in that a nano-supported catalytic layer is provided that may include in various embodiments: two salts (page 7, line 21-24 and page 9, lines 8-22) or two metallic elements, e.g., an active catalytic metallic element and a structural metallic element (page 12, line 1 to page 13, line 4) that combine to form the nano-supported catalytic layer. The advantages provided by the use of this nano-supported catalytic layer are described at page 11, lines 9-23 where it says:

> "The nano-support provided by the metal oxide support maintains the nano-scale dimensions of the active catalytic particles through the useful temperature of the catalytic process including the chemical reaction process subsequently described in this detailed description of the drawings for growing nanotubes and prevents the active catalytic particles from coalescing during such a catalytic process. This nano-support renders the particle size relatively independent of the thickness of the nano-supported catalyst layer 22 and temperature cycle. Furthermore, the metal oxide support can minimize diffusion of poisons to the nano-supported catalyst layer 22 and can enhance chemical reactivity. Due to the nano-supported structure, the nano-supported

catalyst layer 22 has a high surface area and a high surface area to volume ratio."

Lee teaches forming a catalytic metal film of a metal or an alloy of at least two among them (column 4, lines 15-19). Lee does not teach the use of a nano-supported catalytic layer that includes a second element such as the structural metallic element. Lee teaches etching away the entire layer except for islands (particles) left behind to serve as "bases" for growing nanotubes thereon. The present invention etches only a relative thin layer portion of the nano-supported catalytic layer leaving a portion of the second element. This etching in the present invention prevents coalescing, with the resulting size of the nanotubes being determined by the composition of the nano-supported catalytic layer, independent of the thickness of the nano-supported catalyst layer and the temperature used during the etch. Lee is not so independent of the temperature. In Lee, to use a temperature below 650° Celsius, nanotubes much larger than 20 nanometers would be achieved. In order to get nanotubes smaller than 20 nanometers, the process taught by Lee would require a temperature above 650° Celsius, resulting in the destruction of a glass substrate. By not coalescing (the particles being separated by the second element material), the present invention provides smaller nanotubes having a better distribution with an improved density on a substrate having a deformation temperature that is less than about six hundred and fifty degrees Celsius.

Furthermore, the present invention provides for a switching voltage for triggering nanotube emission of less than 80 volts and a current density drawn from the field emission device of less than 0.5 miliamps/cm^2 (page 33, lines 1-4). Lee does not address such factors.

More specifically, claim 1 as amended describes a substrate with a deformation temperature that is less than about six hundred and fifty degrees Celsius, a nano-supported catalyst having active catalytic particles that are less than about five hundred nanometers in diameter and, a nanotube that is catalytically formed in situ on said nano-supported catalyst, said nanotube having a diameter that is less than about twenty nanometers and configured to provide a switching voltage that is less than about eighty volts so that a current density drawn from said field emission device is greater than about one-half milliamp per squared centimeter.

Claims 2, 3 and 14 have been cancelled.

Claims 4, 6-8, 12 and 15-16 are believed allowable since at least they depend from amended claim 1. All of the limitations are believed to make the respective dependent claim allowable at least when taken in conjunction with independent claim 1.

Additionally, claim 4 teaches catalytically forming the nanotube in situ on the nano-supported catalyst with hot filament chemical vapor deposition.

Claim 6 calls for the diameter of the active catalytic particles to be less than 50 nanometer.

Claim 7 calls for the diameter of the nanotube to be less than 5 nanometers.

Claim 8 defines the aspect ratio.

Claim 12 lists materials that may be used for the substrate.

Claim 15 gives the distance between the substrate and anode as greater than about two hundred and fifty microns and less than about five thousand microns.

Claim 16 limits the nano-supported catalyst to less than one micron.

Accordingly, it is believed that the rejection of claims 1, 4, 6-8, 12, and 15-16 under 35 U.S.C. 102 has been overcome by the amendment and remarks.

REJECTION OF CLAIMS 1-7, 9-14, AND 16-17 UNDER 35 U.S.C. §103

Claims 1-7, 9-14, and 16-17 have been rejected under 35 U.S.C. 103 as being unpatentable over Xu et al. (5,872,422) in view of Lee et al. (6,514,113).

The Xu patent reference discloses, in a first method, a carbon fiber-based field emission device wherein carbon fibers are grown on a catalytic metal film overlying a substrate. It should be noted that carbon fibers as described by Xu are quite different from carbon nanotubes. Fibers are bigger in diameter and much less dense. In a first embodiment, the catalytic metal film may comprise one of, a mix of, or an alloy of a number of metals (see column 11, lines 20-26). In another embodiment, the metal film may be patterened as "particles" (column 11, lines 30-32) by heating, causing the metal film to nucleate and leaving small clusters (particles, or islands) (column 19, lines 42-47). In yet another embodiment (column 20, Example 3), it is taught to place "particles" on the substrate by suspending iron oxide particles in a

solution having a high carbon concentration, dispersing the solution onto the substrate, and heating to remove the solution while leaving the particles (islands) behind.

The Lee reference and the present invention have been described above in responding to the §102 rejection.

The present invention differs from the cited Xu patent in that the present invention provides a nano-supported catalytic layer that may include in various embodiments: two salts (page 7, line 21-24 and page 9, lines 8-22) or two metallic elements, e.g., an active catalytic metallic element and a structural metallic element (page 12, line 1 to page 13, line 4) that combine to form the nano-supported catalytic layer. The advantages provided by the use of this nano-supported catalytic layer are described at page 11, lines 9-23 where it says:

> "The nano-support provided by the metal oxide support maintains the nano-scale dimensions of the active catalytic particles through the useful temperature of the catalytic process including the chemical reaction process subsequently described in this detailed description of the drawings for growing nanotubes and prevents the active catalytic particles from coalescing during such a catalytic process. This nano-support renders the particle size relatively independent of the thickness of the nano-supported catalyst layer 22 and temperature cycle. Furthermore, the metal oxide support can minimize diffusion of poisons

to the nano-supported catalyst layer 22 and can enhance chemical reactivity. Due to the nano-supported structure, the nano-supported catalyst layer 22 has a high surface area and a high surface area to volume ratio."

Xu teaches forming a catalytic metal film of a metal or an alloy of at least two among them (column 4, lines 15-19). Xu does not teach the use of a nano-supported catalytic layer that includes a second element such as the structural metallic element. Xu teaches etching away the entire layer except for islands (particles) left behind to serve as "bases" for growing nanotubes thereon. The present invention etches only a relative thin layer portion of the nano-supported catalytic layer leaving a portion of the second element. This etching in the present invention prevents coalescing, with the resulting size of the nanotubes being determined by the composition of the nano-supported catalytic layer, independent of the thickness of the nano-supported catalyst layer and the temperature used during the etch. Xu is not so independent of the temperature. In Xu, to use a temperature below 650° Celsius, nanotubes much larger than 20 nanometers would be achieved. In order to get nanotubes smaller than 20 nanometers, the process taught by Lee would require a temperature above 650° Celsius, resulting in the destruction of a glass substrate. By not coalescing the particles being separated by the second element material), the present invention provides smaller nanotubes having a better distribution with an improved density.

Furthermore, the present invention provides for a voltage switch of less than 80 volts and a current density of less than 0.5 miliamps/cm^2 (page 33, lines 1-4). Xu provides a graph (FIG. 12) that gives emission current as a function of anode voltage for a single nanotube that does not teach these advantages of the present invention.

In summary, both Xu and Lee teach providing islands of a catalyst for growing fiber or nanotubes, respectively, thereon. In one embodiment, Xu describes providing carbon fibers on a layer (not islands) of a catalytic material (without the supporting element). Neither teach or suggest providing a nano-supported catalyst which comprises a catalytic element (particles) and a structural element, whether they be salts or metals.

More specifically, claim 1 as amended describes a substrate with a deformation temperature that is less than about six hundred and fifty degrees Celsius, a nano-supported catalyst having active catalytic particles that are less than about five hundred nanometers in diameter and, a plurality of nanotubes that are catalytically formed in situ on said nano-supported catalyst, said nanotube having a diameter that is less than about twenty nanometers and configured to provide a switching voltage for triggering nanotube emission that is less than about eighty volts so that a nanotube emission current density drawn from said field emission device is greater than about one-half milliamperes per squared centimeter of the anode.

Claims 2, 3 and 14 have been cancelled.

Claims 4-7, 9-13 and 16-17 are believed allowable since at least they depend from amended claim 1. All of the limitations are believed to make the respective dependent claim allowable at least when taken in conjunction with independent claim 1.

Additionally, claim 4 teaches catalytically forming the nanotube in situ on the nano-supported catalyst with hot filament chemical vapor deposition.

Claim 5 states the switching voltage to be less than 50 volts.

Claim 6 calls for the diameter of the active catalytic particles to be less than 50 nanometer.

Claim 7 calls for the diameter of the nanotube to be less than 5 nanometers.

Claim 9 defines the nanotubes as being single walled.

Claim 10 defines the nanotubes as being multi-walled.

Claim 11 add that the current density is greater than about one and one-half milliampere per squared centimeter.

Claim 12 lists possible materials for the substrate.

Claim 13 defines the gate spacing as less than about twenty-five microns.

Claim 16 limits the nano-supported catalyst to less than one micron.

Claim 17 gives materials suitable for the nano-supported catalyst particles.

Accordingly, it is believed that the rejection of claims 1-7, 9-14, and 16-17 under 35 U.S.C. 103 has been overcome by the amendment and remarks.

ALLOWABLE CLAIMS

Claims 18 and 19 have been identified as being allowable if rewritten as independent claims. These claims are now believed allowable since they depend from what is believed to be an allowable independent claim.

NEWLY SUBMITTED ART

Several references have been submitted simultaneously in an Information Disclosure Statement with this amendment. Although the references may show a way of growing nanotubes on a catalytic material, none teach or suggest a nano-supported substrate as discussed above in differentiating Xu and Lee.

RELATED CASES

Applicant would like to note that it is assignee of other cases related to the subject technology, including U.S. Patent 6,596,187 and U.S. Application Number 09/942,496 both filed on the same day as the present case; and U.S. Application Numbers 09/932,642; 09/940,756; 10/024,164; and 10/356,217.

The remaining cited references have been reviewed and are not believed to affect the patentability of the claims as amended.

No amendment made herein was related to the statutory requirements of patentability unless expressly stated; and no amendment made herein was for the purpose of narrowing the scope of any claim, unless Applicant has argued herein

that such amendment was made to distinguish over a particular reference or combination of references.

The Commissioner is hereby authorized to charge any fees which may be required or credit any overpayment to deposit account #502117.

In view of the above, it is submitted that the claims are in condition for allowance. Reconsideration of the rejections is requested.

Respectfully submitted,
DEAN ET AL.

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